



**Carnegie Mellon**  
**Software Engineering Institute**

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# Software Design-for-Six Sigma (SDFSS) and SEI Technologies meet!

By Robert W. Stoddard  
Motorola Six Sigma Master Black Belt  
Senior Member of Technical Staff  
Software Engineering Institute  
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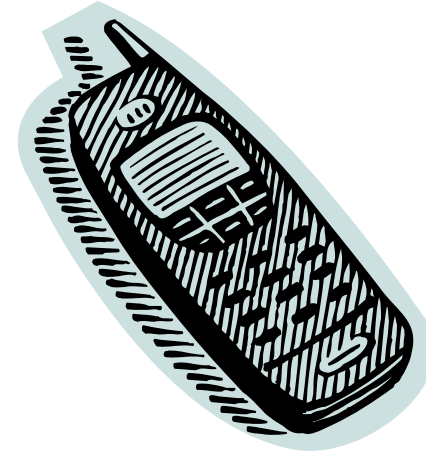
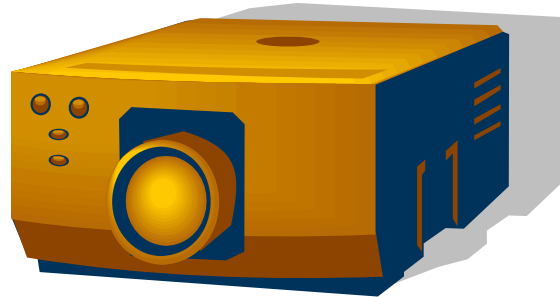
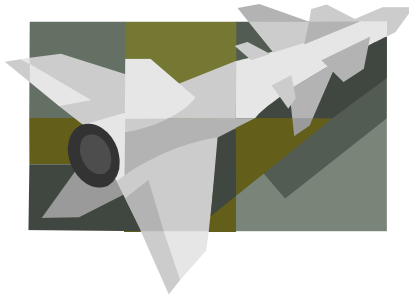
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- CMMI®
- SEI's Architecture Tradeoff Analysis Method®
- ATAM®

# Product Experience



# SDFSS Opportunities

## Impacts without SDFSS

- Multi-year development projects failed to deliver a working product (min cost=\$7M)
- Failure 1: Did not model performance of new chipset, processor or language
- Failure 2: Did not adequately characterize the market and business case
- Failure 3: Did not adequately test the product

## Benefits with SDFSS

- Business cases modeling all reasonable uncertainties in market and customer segments
- Schedules with uncertainties modeled
- Req'ts identified, with KJ analysis, to delight customers
- Design of Experiments used to: optimize and patent fuel efficiency; test object-oriented software; test robustness with fault insertion testing; reduce flight test by 10x



## Purpose of this Talk

- To proclaim that software DFSS, within a holistic DFSS approach to product development, is coming of age,
- To demonstrate that many gaps, in translating traditional DFSS concepts to software engineering, may be solved by the adoption of a number of Software Engineering Institute (SEI) technologies.

*Thus, DFSS does not have to be re-invented for Software Engineering!*

# Target Audience

- Executives and Directors contemplating investing in Software DFSS
- Deployment champions who may be tasked with the training and roll-out of Software DFSS
- DFSS and Software Engineering Leaders who need to understand both disciplines, and who can lead in translating and interpreting key concepts and tools between the two disciplines.

# A Philosophy

From the inception of Six Sigma, the overriding objective has been “the degree of confidence a customer has that his (or her) product and service-related expectations will be met by the producer.”<sup>1</sup>

Today, it is “a business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction.”<sup>2</sup>

<sup>1</sup> Michael J. Harry & J. Ronald Lawson, “*Six Sigma Producibility Analysis and Process Characterization*,” Addison-Wesley Publishing Company, Inc., 1992.

<sup>2</sup> Michael J. Harry, & Richard Schroeder, “*Six Sigma: The Breakthrough Management Strategy Revolutionizing the World’s Top Corporations*”, 2000.



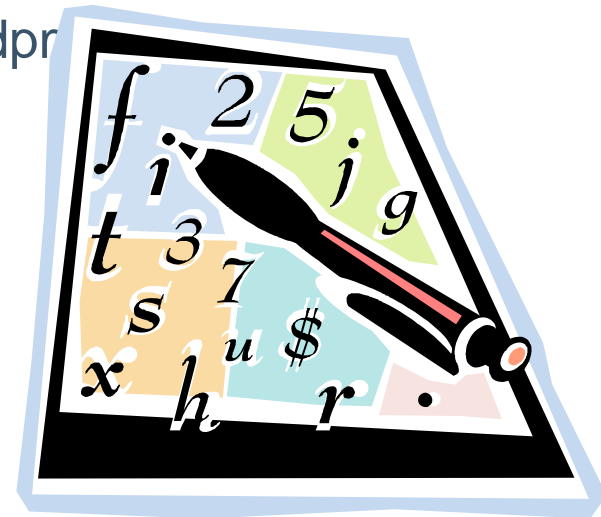


## Example Six Sigma Measures

The most-cited measure is “3.4 ppm.”

Other measures

- defect rate, parts per million (ppm)
- Sigma level
- defects per unit (dpu)
- defects per million opportunities (dpmo)
- yield



# Alternative Six Sigma Approaches

DMAIC	Define-Measure-Analyze-Improve-Control	To solve problems and drive incremental business improvements (e.g. fine-tuning an existing process or product)
DMAD(O)V	Define-Measure-Analyze-Design-(Optimize)-Verify	To solve problems and drive radical improvement (e.g. blowing up and re-engineering an existing process or product)
Lean	5S's; Value Stream Mapping; Cycle Time Analysis	To lean a process by simplification, reducing non-value added tasks, optimizing cycle times
DFSS	Design-For-Six-Sigma	Applying the Six Sigma toolkit and intent to product development beginning with portfolio, marketing, engineering, research, sales, and supply chain

# Holistic View of Software DFSS

Portfolio for Six Sigma

Marketing for Six Sigma

Product Commercialization for Six Sigma

Technology Platform R&D for Six Sigma

Sales & Distribution for Six Sigma

Supply Chain for Six Sigma

# Holistic View of Software DFSS

## Portfolio for Six Sigma

### Using Statistical Methods:

\* Adapted from Clyde Creveling, *Marketing for Six Sigma* and *Product Development with Six Sigma*

1. Identify Opportunities, Markets and Market Segments,
2. Gather Long Range Voice of the Customer,
3. Obtain Technology Roadmap and Technology Characterizations from the R&D / Platform Group,
4. Define Product Portfolio Requirements,
5. Generate Product Portfolio Architectures,
6. Support Portfolio decisions with Real-Options analysis
7. Evaluate and Select a Product Portfolio, and
8. Develop a Prioritized List of Products within a Product Line Strategy.

# Holistic View of Software DFSS

## Portfolio for Six Sigma

### Marketing for Six Sigma

#### Using Statistical Methods:

\* Adapted from Clyde Creveling, *Marketing for Six Sigma* and *Product Development with Six Sigma*

1. Understand Customer Value and create a Customer Value Dashboard,
2. Develop the Value Stream analysis,
3. Conducting Marketing FMEA risk analysis and Business SWOT,
4. Creating Marketing Process measures and data collection methods,
5. KJ and Kano Analysis,
6. Marketing Composite Design and Product Line Strategies
7. Market Forecasting, Price Model Planning, Channel Analysis,
8. Portfolio Management, Branding Decision-making and Promotion Analysis



# Holistic View of Software DFSS

## Portfolio for Six Sigma

### Marketing for Six Sigma

### Product Commercialization for Six Sigma

#### Using Statistical Methods:

\* Adapted from Clyde Creveling, *Marketing for Six Sigma* and *Product Development with Six Sigma*

1. Participate in KJ and QFD Voice of the Customer Activities,
2. Develop functional models, architecture and behavioral models,
3. Generate product solution concepts and identify critical parameters for CTQs,
4. Develop mathematical and statistical models of CTQs,
5. Select solution, implement robust design and track Critical Parameters,
6. Create optimized designs using designed experiments,
7. Establish critical parameter tolerances, and verify CTQ achievement.



# Holistic View of Software DFSS

Portfolio for Six Sigma

Marketing for Six Sigma

Product Commercialization for Six Sigma

Technology Platform R&D for Six Sigma

## Using Statistical Methods:

1. Characterize existing technologies, capabilities, gaps, risks, expected life
2. Identify and evaluate anticipated technology breakthroughs including probabilistic assessment of timing and capability
3. Optimize the portfolio of technologies to be pursued in context of the business strategy and latest product portfolio
4. Develop robust platforms that are optimized for the Customer Req'ts and CTQs of product lines
5. Develop performance models of platform technology and its capabilities



# SEI Technologies Boost DFSS!

Portfolio for Six Sigma

Marketing for Six Sigma

Product Commercialization

Technology Platform R&D for Six Sigma

Sales & Distribution for Six Sigma

Supply Chain for Six Sigma

The **SEI Capability Maturity Model Integrated (CMMI)**

has a product development perspective that overlaps significantly with all of the DFSS methodologies!



# CMMI & Six Sigma (DFSS) Connections

- Many connections exist, specifically with the following basic process areas:
  - RD, REQM, TS
  - VER, VAL
  - DAR, RSKM, MA
- Connections are further highlighted on the following slides with CMMI High Maturity Process Areas:
  - QPM, OPP
  - CAR, OID

# CMMI OPP and Six Sigma

SP1.1 Processes		Big Y Business Goal-to-Vital x Process; Processes driving central tendency and variation
SP1.2 Measures		Critical Parameter Management; CTQ factors; Root Cause Analysis of subprocess factors
SP1.3 Objectives		KJ Analysis®; Analytic Hierarchy Process; Categorical Survey Data Analysis; Six Sigma Scorecards
SP1.4 Baselines		Control Charts; Graphical Summaries in Minitab; Central Tendency and Variation; Confidence and Prediction Intervals
SP1.5 Models		ANOVA; Regression; Chi-Square; Logistic Regression; Monte Carlo Simulation; Discrete Event Process Simulation; Design of Experiments; Response Surface Methodology; Multiple Y Optimization; Probabilistic Models

# CMMI QPM and Six Sigma

SG1

Quantitatively  
Manage the  
Project



KJ Analysis®; Analytic Hierarchy Process;  
Categorical Survey Data Analysis; Six Sigma  
Scorecards; Big Y Business Goal-to-Vital x  
Process; Process Mapping Methods and Value-  
Stream Analysis;  
Processes driving central tendency and variation;  
Critical Parameter Management; CTQ factors; Root  
Cause Analysis of Sub-process factors; Cockpit

SG2

Statistically  
Manage  
Subprocess  
Performance

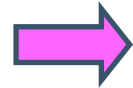


Control Charts; Graphical Summaries in Minitab;  
Central Tendency and Variation; Confidence and  
Prediction Intervals; ANOVA; Regression; Chi-  
Square; Logistic Regression; Monte Carlo  
Simulation; Discrete Event Process Simulation;  
Design of Experiments; Response Surface  
Methodology; Multiple Y Optimization; Probabilistic  
Models



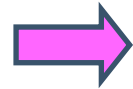
## CMMI CAR and Six Sigma

SP1.1 Select  
Defect Data for  
Analysis



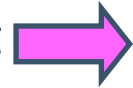
Measure Phase tools and methods within DMAIC or DMAD(O)V; Models provide insight to the areas of defect data to concentrate on

SP1.2 Analyze  
Causes



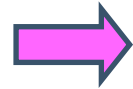
Root Cause Methods, e.g. Ishikawa Diagrams, statistical hypothesis tests to determine if segments are different

SP2.1 Implement  
the Action  
Proposals



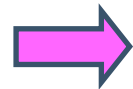
Piloting; Comparative Studies; Technological and Cultural Change Management techniques

SP2.2 Evaluate  
the Effect of  
Changes



Before and After studies and Hypothesis tests; Survey categorical data analysis; compare to results of prediction models

SP2.3 Record  
Data



Study results; Lessons Learned shared across the organization; Institutional learning

# CMMI OID and Six Sigma

SG1 Select  
Improvements



Six Sigma Big Y to Vital x semi-annual workshops;  
Business Goal simulation and optimization models;  
Benchmarking; Capability data sharing; Theory of  
Inventing (TRIZ) methods; Usage of performance  
models to identify the major opportunities for  
improvement with innovation; Assumption Busters;  
Empowered innovative thinking; Incentives for  
Innovation; Strong Teaming for Innovation;  
Various decision models such as AHP, Pugh  
Method, Probabilistic decision trees

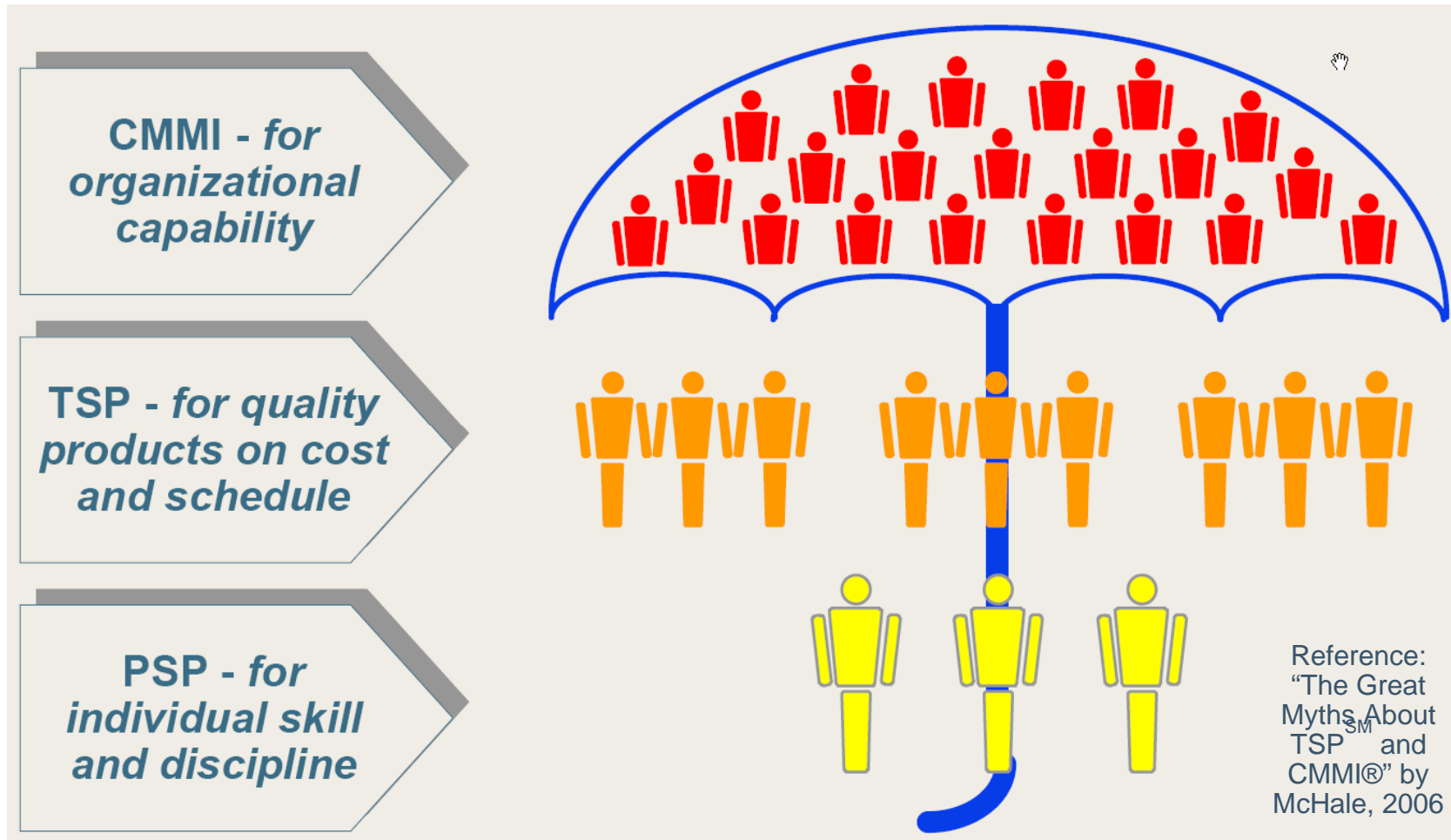
SG2 Deploy  
Improvements



Process and Design FMEA; Organizational  
Readiness for Change; Change Agents;  
Sponsors; Champions; Influence Leaders;  
Adoption Curve; Piloting; Risk-based deployment;  
Before and After comparisons with Hypothesis  
tests; Results compared to prediction models;  
Proactive mitigation of risks



# The CMMI, TSP and PSP



# SEI Technologies Boost DFSS!

## Portfolio for Six Sigma

Marketing for Six Sigma

Product Commercialization for Six Sigma

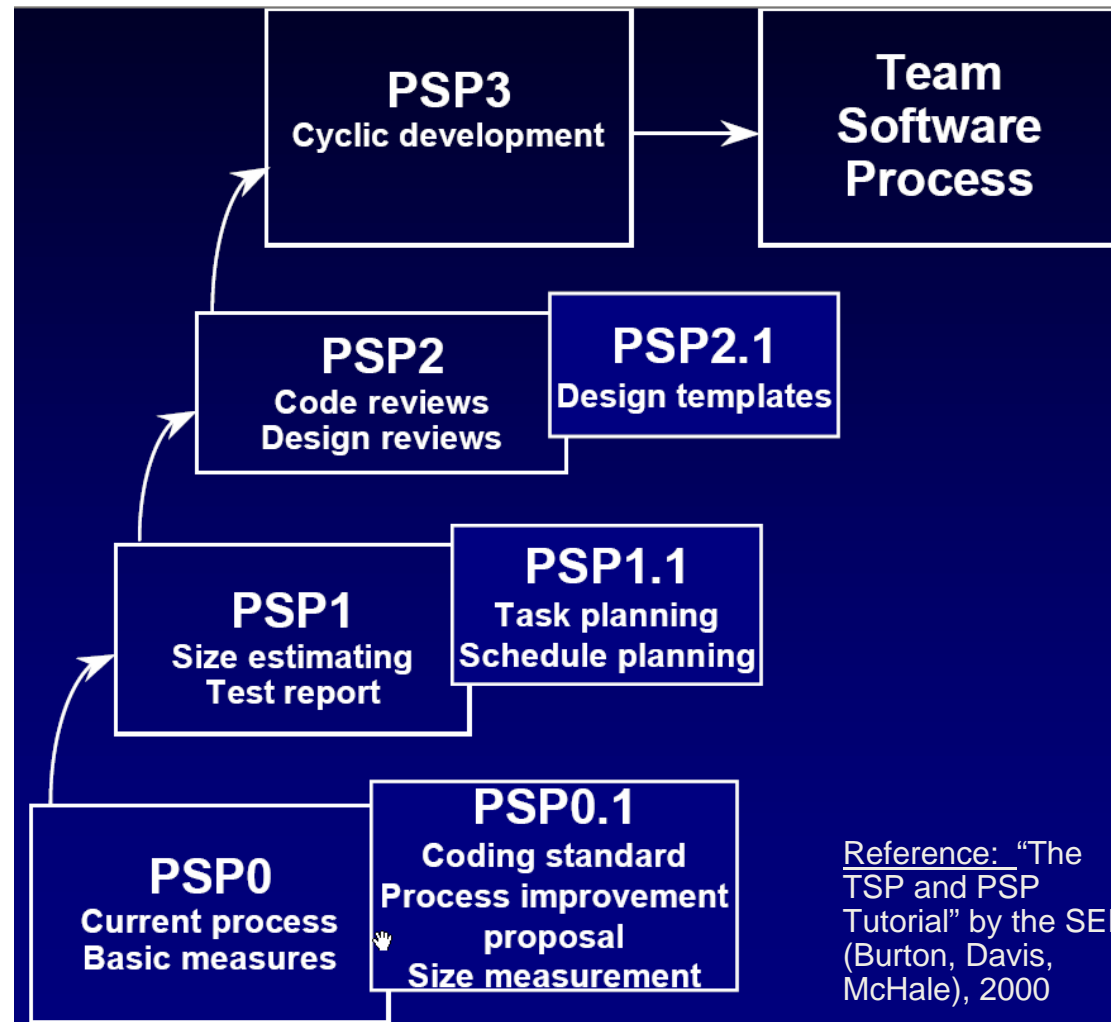
Technology Platform R&D for Six Sigma



The **SEI Team Software Process (TSP)** and **Personal Software Process (PSP)** significantly enhance the software development teaming within Product Commercialization and Technology Platform R&D for Six Sigma!



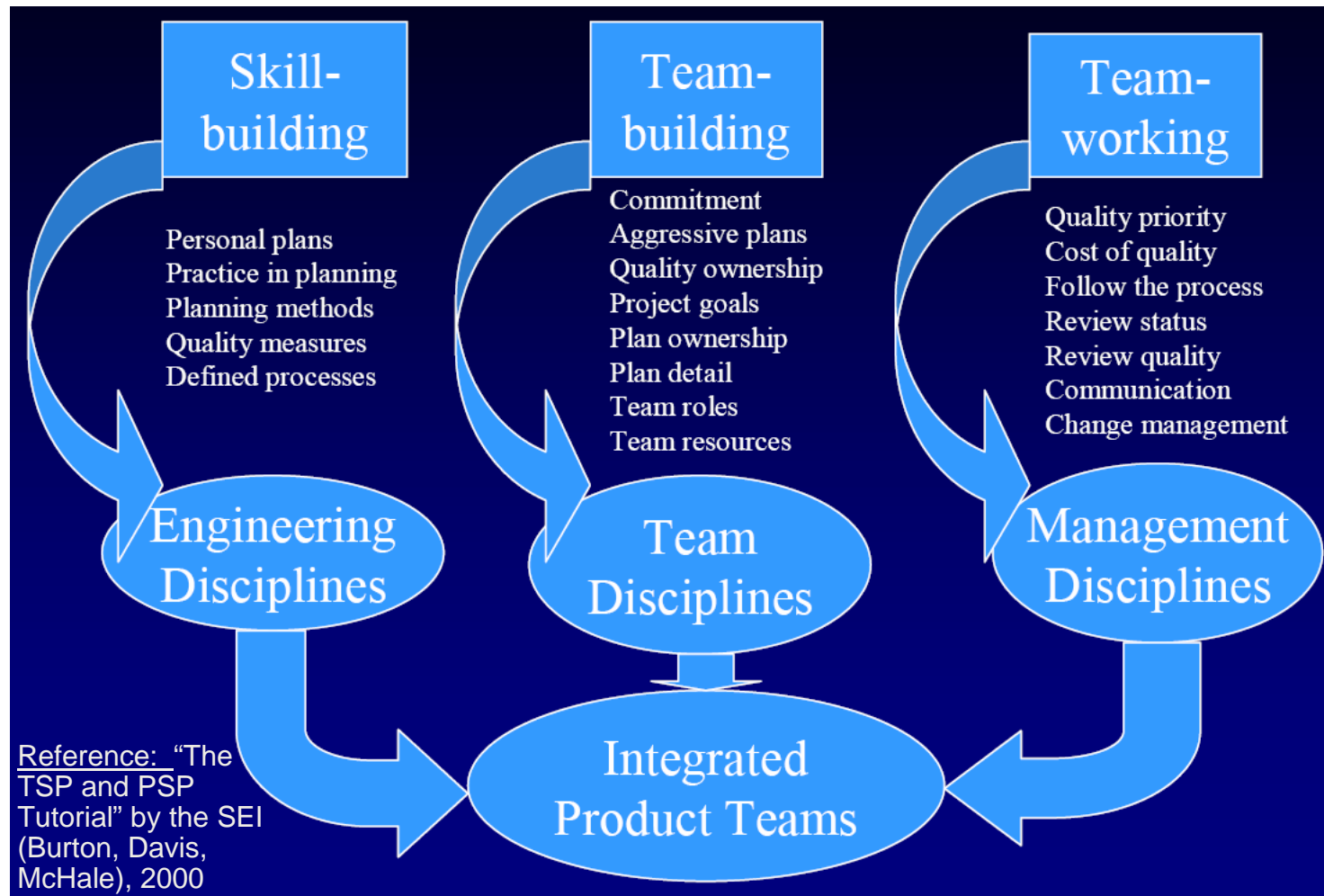
# The Personal Software Process





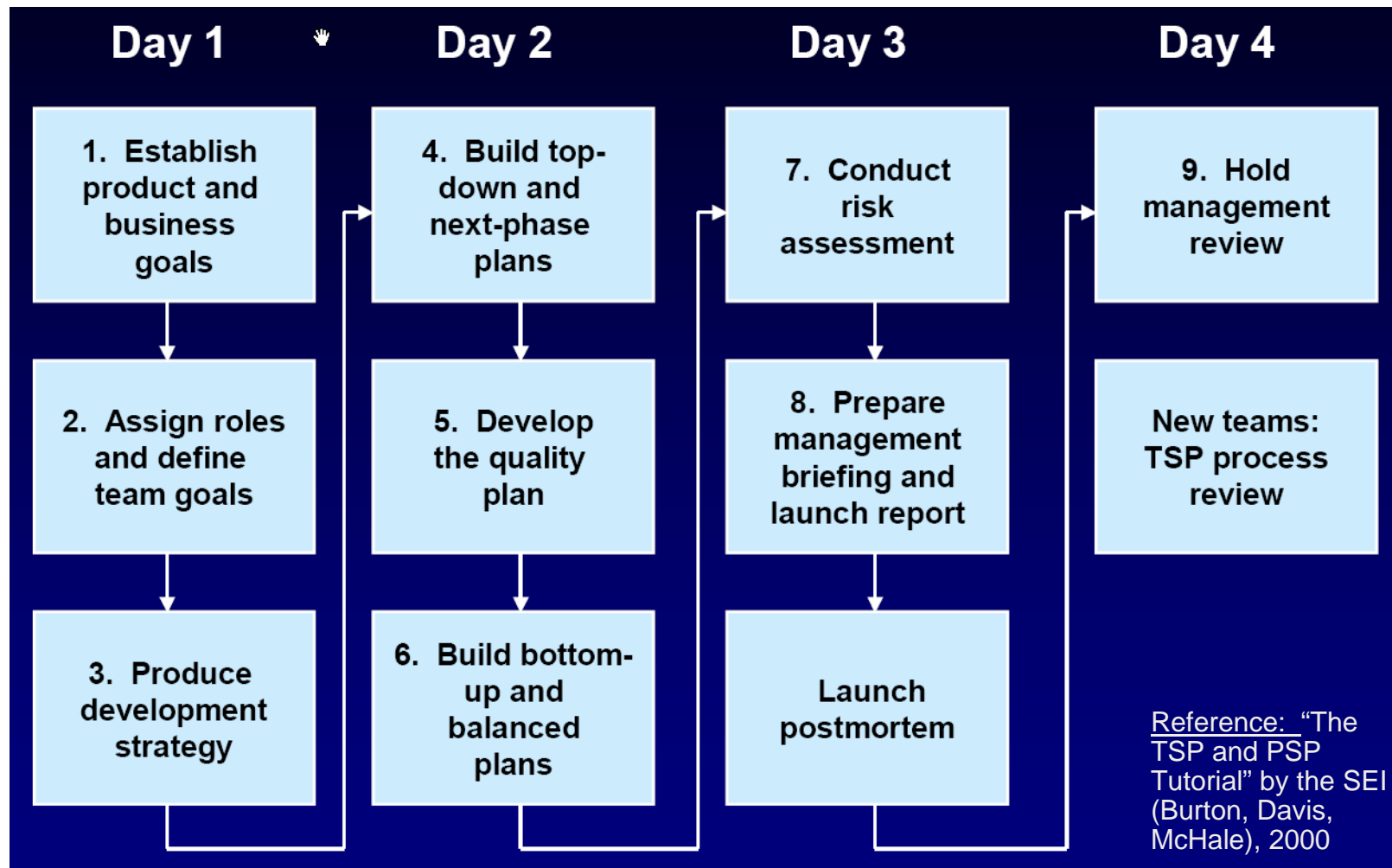


# TSP Builds Software Teams



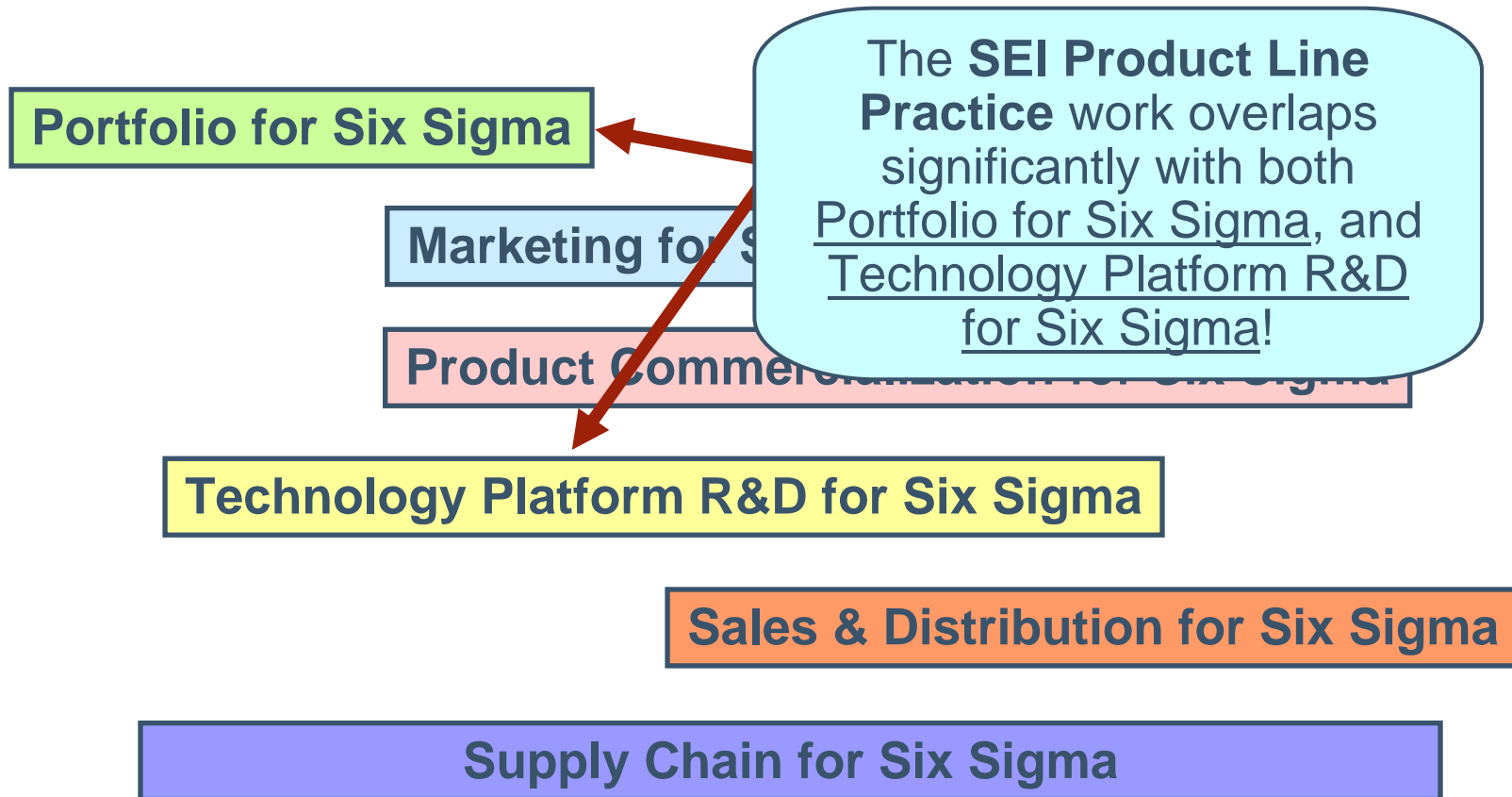


# The TSP Launch Process



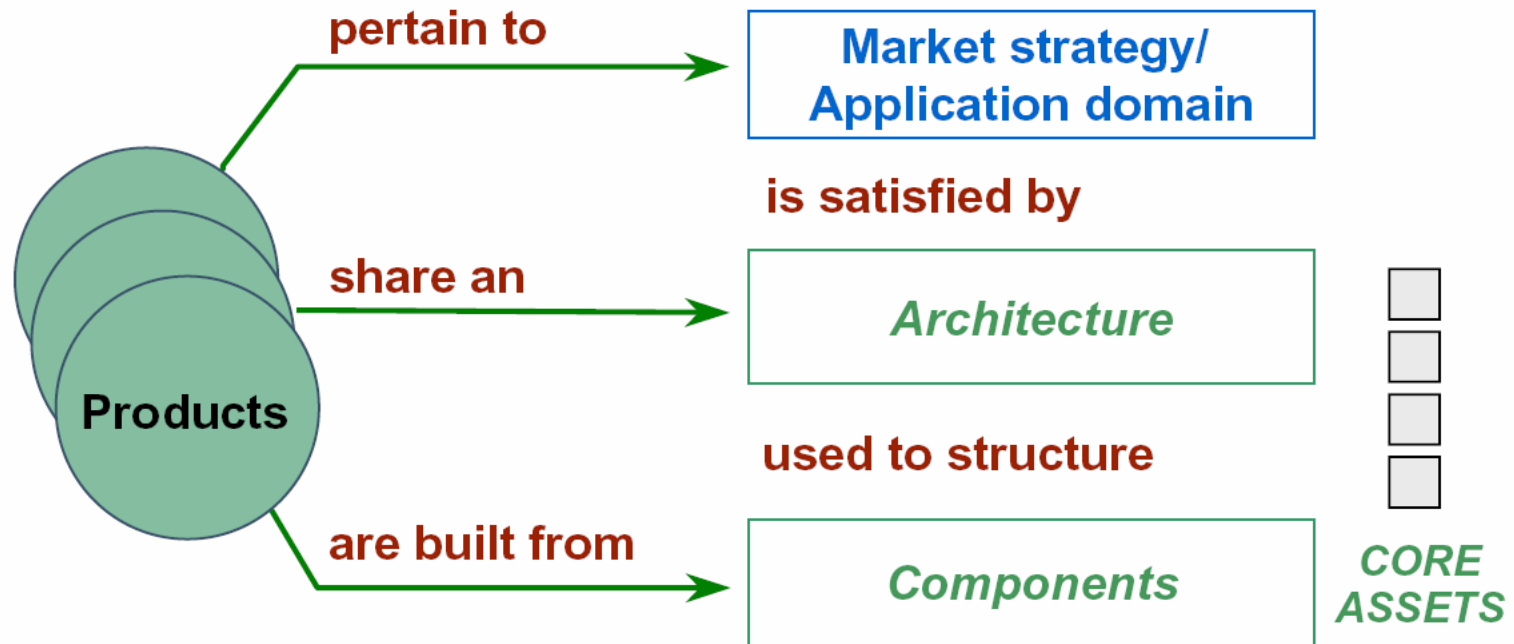


# SEI Technologies Boost DFSS!





# Software Product Lines



## Product lines

- take economic advantage of commonality
- bound variability

Reference: "Software Product Lines", Paul Clements, Linda Northrop, 2003.



# Product Line Practice Framework



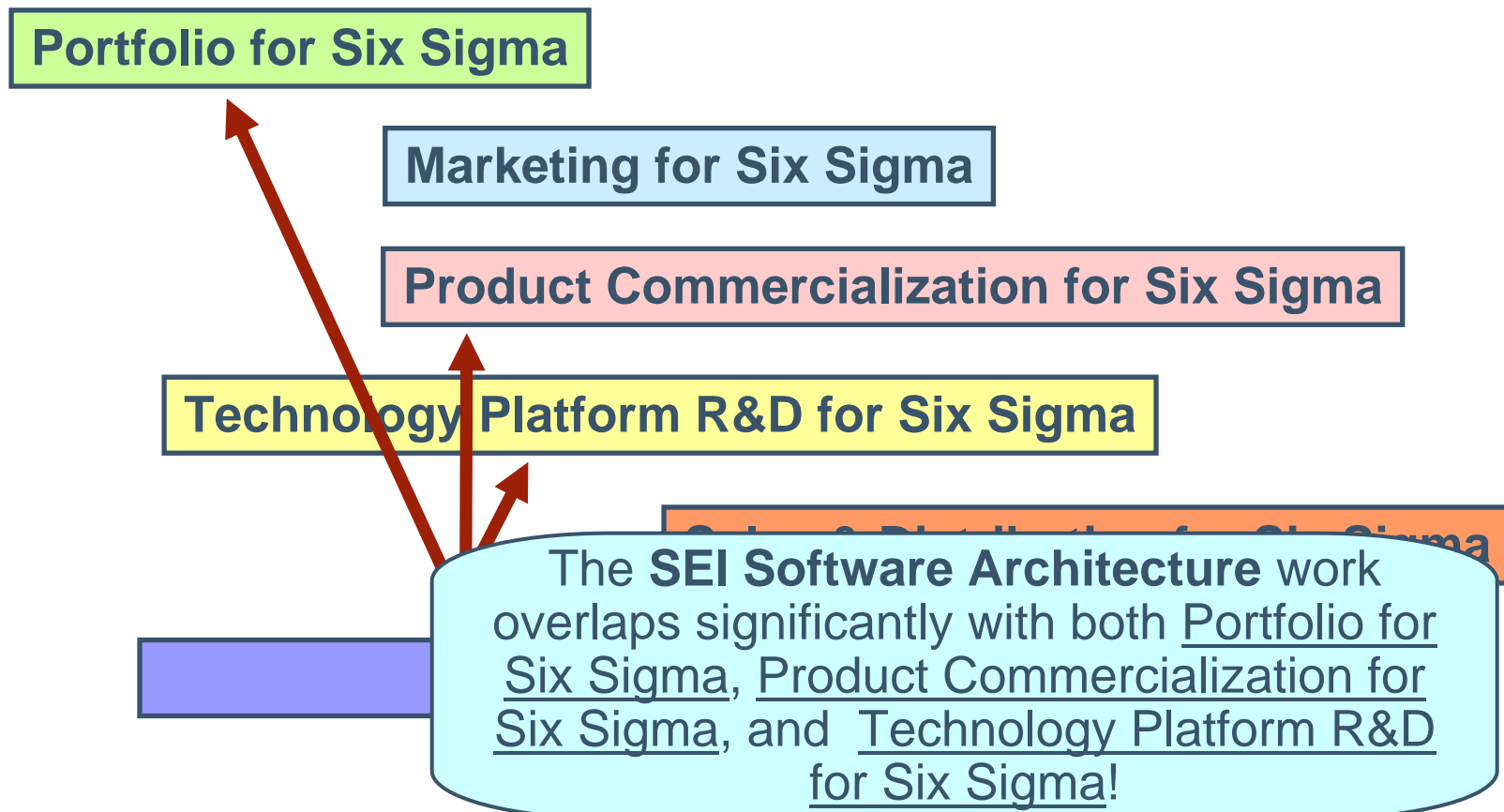
Reference: "Software Product Lines", Paul Clements, Linda Northrop, 2003.

## Essential Activities

Architecture Definition Architecture Evaluation Component Development COTS Utilization Mining Existing Assets Requirements Engineering Software System Integration Testing Understanding Relevant Domains	Configuration Management Data Collection, Metrics, and Tracking Make/Buy/Mine/Commission Analysis Process Definition Scoping Technical Planning Technical Risk Management Tool Support	Building a Business Case Customer Interface Management Implementing an Acquisition Strategy Funding Launching and Institutionalizing Market Analysis Operations Organizational Planning Organizational Risk Management Structuring the Organization Technology Forecasting Training
<b>Software Engineering</b>	<b>Technical Management</b>	<b>Organizational Management</b>



# SEI Technologies Boost DFSS!



## **Software Architecture Technology (SAT) Initiative's Focus**

Ensure that business and mission goals are predictably achieved by using effective software architecture practices throughout the development lifecycle.

### Axioms Guiding Our Work

- Software architecture is the bridge between business and mission goals and a software-intensive system.
- **Quality attribute requirements drive software architecture design.**
- Software architecture drives software development throughout the life cycle.

Reference: “Future Directions of the Software Architecture Technology Initiative”, Second Annual SATURN Workshop, Mark Klein, 2006

## SEI's Architecture Tradeoff Analysis Method® (ATAM®)

ATAM is an architecture evaluation method that

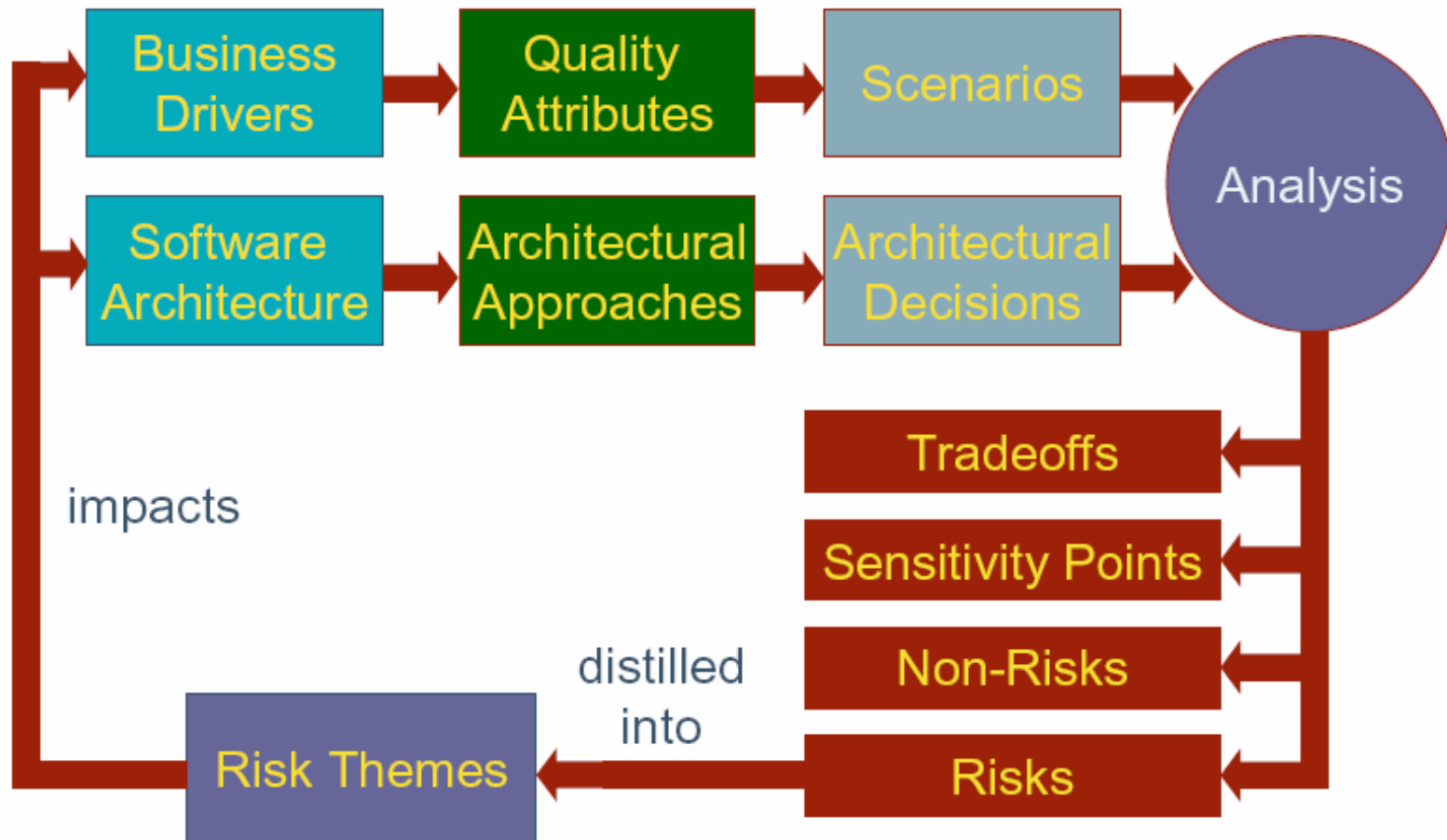
- focuses on multiple quality attributes
- illuminates points in the architecture where quality attribute *tradeoffs* occur
- generates a context for ongoing quantitative analysis
- utilizes an architecture's vested stakeholders as authorities on the quality attribute goals

Reference: "Future Directions of the Software Architecture Technology Initiative", Second Annual SATURN Workshop, Mark Klein, 2006



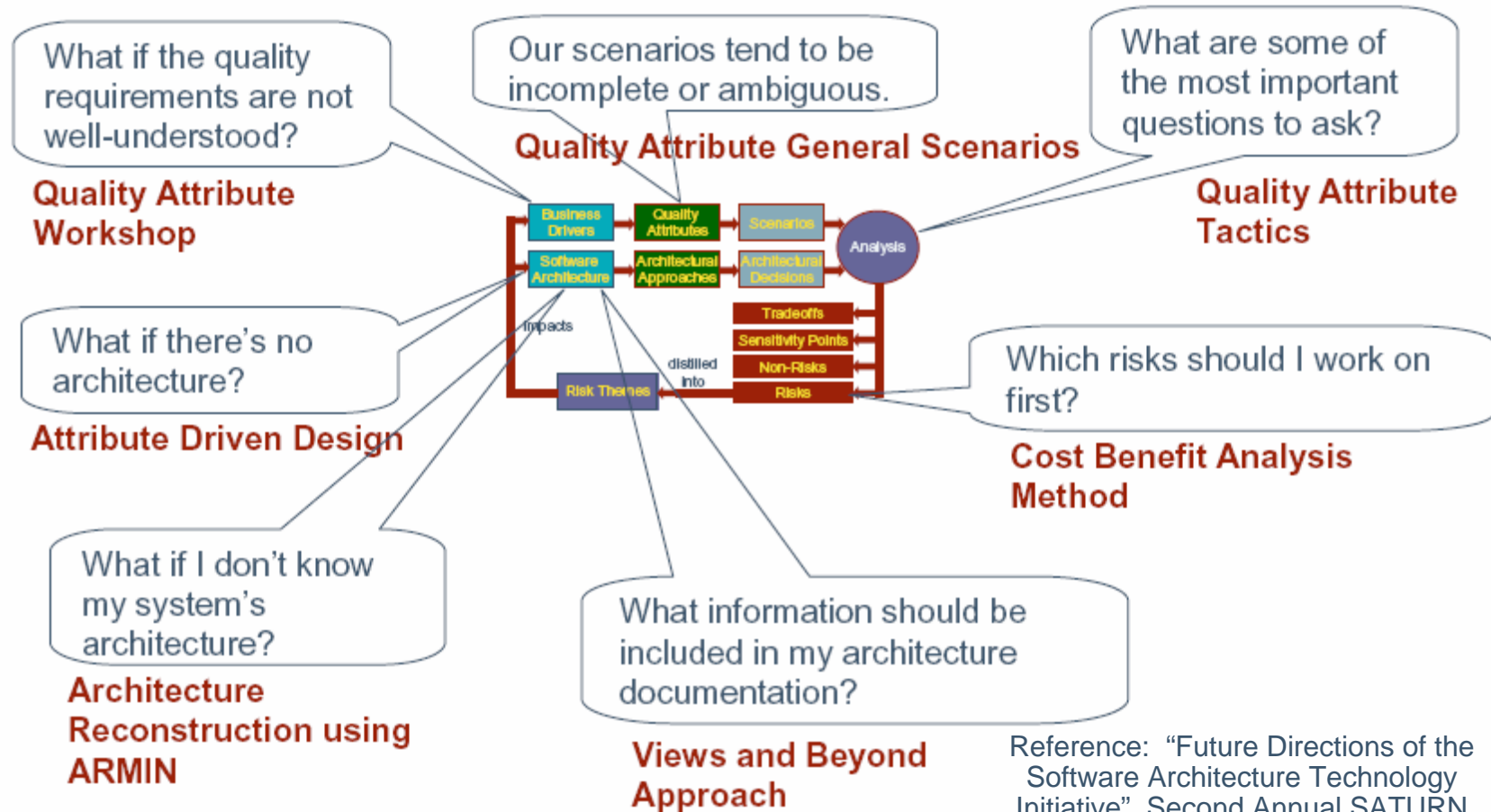


## Conceptual Flow of the ATAM<sup>SM</sup>





## ATAM Led to the Development of Other Methods and Techniques



Reference: "Future Directions of the Software Architecture Technology Initiative", Second Annual SATURN Workshop, Mark Klein, 2006



## In Summary

Software DFSS, within a holistic DFSS approach to product development, is coming of age,

Many gaps, in translating traditional DFSS concepts to software engineering, may be solved by the adoption of a number of Software Engineering Institute (SEI) technologies.

*Thus, DFSS does not have to be re-invented for Software Engineering!*



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## Contact Information

Robert Stoddard  
Software Engineering Institute (Office 3110)  
4500 Fifth Avenue  
Pittsburgh, PA 15213  
412.268.1121  
[rhs@sei.cmu.edu](mailto:rhs@sei.cmu.edu)

Or, contact SEI Customer Relations:

Customer Relations  
Software Engineering Institute  
Carnegie Mellon University  
Pittsburgh, PA 15213-3890  
FAX: (412) 268-5800  
[customer-relations@sei.cmu.edu](mailto:customer-relations@sei.cmu.edu)

# Questions

